Application of Protective Coating for Rehabilitation of Wisconsin Concrete Bridges

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What Was the Need for the Project and How Does it Effect Bridge Owners in Wisconsin?

- As a Maintenance Engineer for the DOT in Wisconsin for over 20 years , I am also a Certified NBI Bridge Program Manager and am responsible for Bridge as well as Roadway repair and maintenance in the SW Region of Wisconsin.

Some of the Problems in the Field:

- The following slides will show some of the things we were seeing at our beam ends and the problems of salt infiltration not only cosmetically but eventually structurally as well.


04/10/2007


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09/12/2007


09/12/2007

Points of Concern

- Corrosion damage of girder ends
- Water leaking through faulty expansion joints
- Resulting in steel corrosion and the spalling of concrete

Points of Concern

- Repair: complete removal followed by reconstruction
- Common Issues:
  - Reoccurring spalls due to inadequate bond
  - Contaminants in adjacent areas migrate to the repair region

What We Were Doing:

- Spending many dollars and man hours on cleaning and patching with cementitious materials.
- Damage was already done and by patching we only created a cosmetic solution that only lasted a few years.


05/08/2007

What Was Needed:

- A research project that would give an unbiased evaluation of what we were doing wrong and some definitive solutions to fix the problem.
- The evaluations would include many of the coatings and materials readily available to the industry and how they performed. (note: the unique part of this study was the acceleration of the salt infiltration process.)

The Results of the Study:

- Showed us what not to do.
- Provided us with a proactive solution to the problem.
- Changed our Bridge construction manual.
- Saved bridge facility owners money.
- Changed our bridge inspection/repair process.

Future Studies:

- The success of this project has provided us with an opportunity to use existing data and materials to do further study.
- This new project will give us unbiased research to substantiate industry claims on coatings and sealers and other methods of rebar protection, spall prevention, and repair techniques beyond beam ends.

Work at the University of Wisconsin-Milwaukee

Experimental Program Objectives

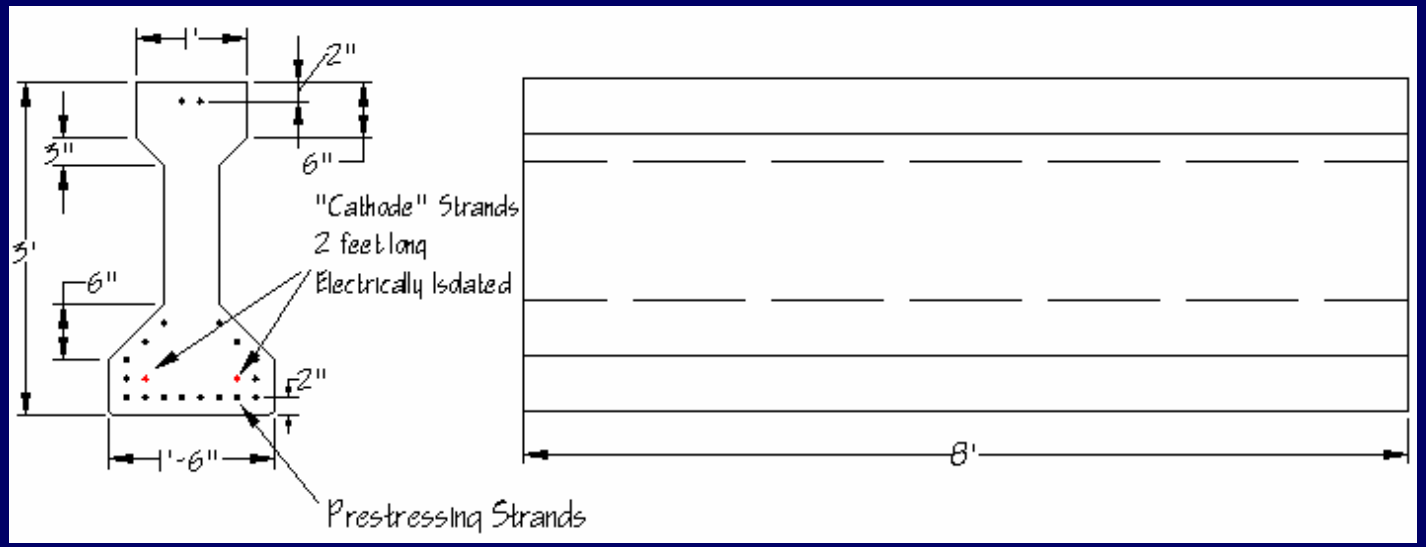
- Determine the effectiveness of a sealer, epoxy coating, polymer (resin) coating, and FRP wrap in protecting against corrosion damage in new members (PS beam ends)
- To establish the effectiveness of these treatments and patch repairs in reducing/preventing continued corrosion in members that are already contaminated with chlorides

Experimental Program Overview

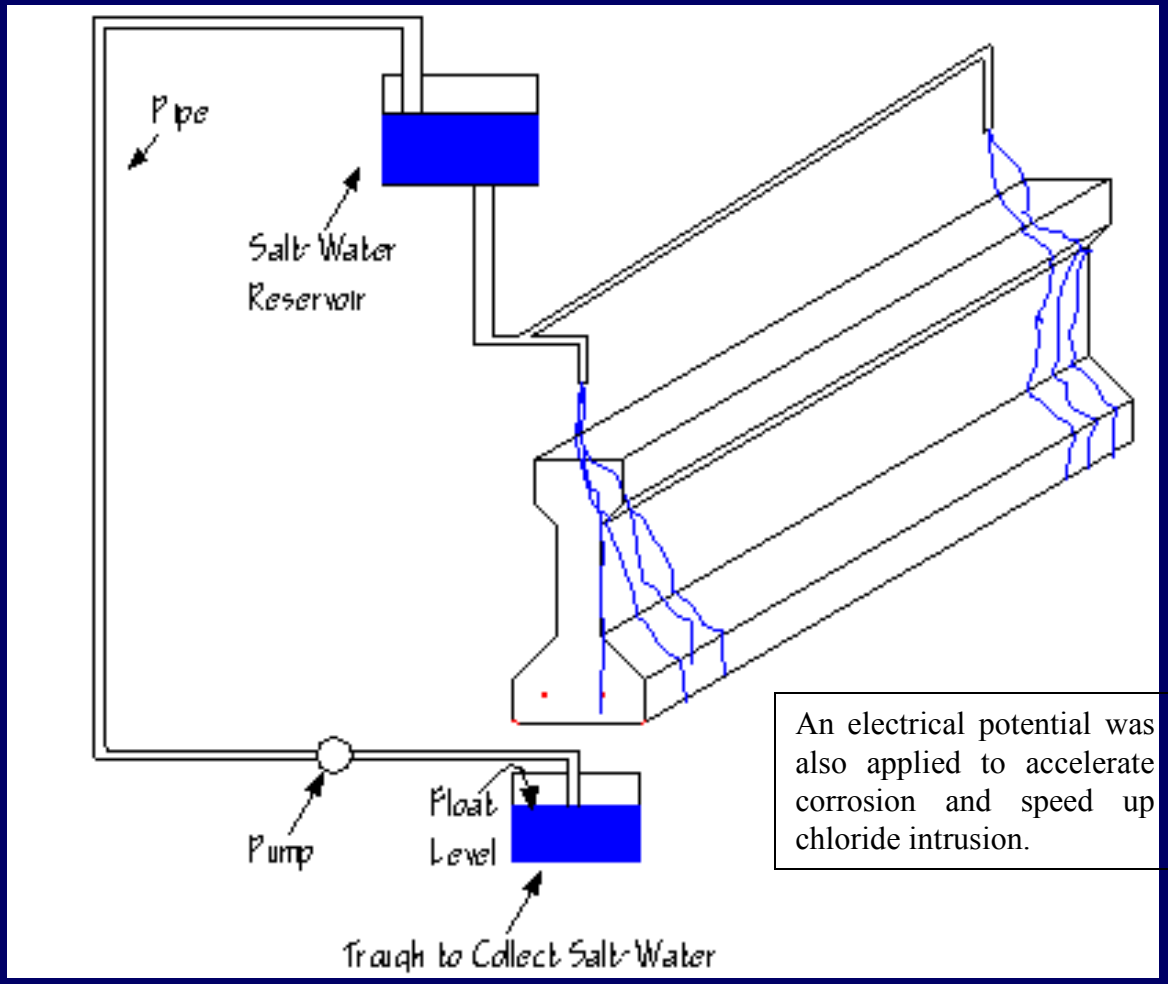
- Performing laboratory tests on five new 8-ft-long prestressed concrete bridge I-beams
  - Subjected to wet/dry cycles of salt laden water (6% NaCl solution) for 18 mo.
  - Subjected to galvanostatic accelerated corrosion methods
- Selected end regions were pretreated, while others remained untreated
- After 6 months, some of the previously untreated beam-ends were patch repaired or subjected to one of the surface treatments

Specimens

- 8-ft long AASHTO Type II prestressed concrete beams
- 18 - ½ inch diameter grade 270 low relaxation 7-wire prestressing strands
- Grade 60 conventional reinforcement
- 2 electrically isolated strands (cathode bars)

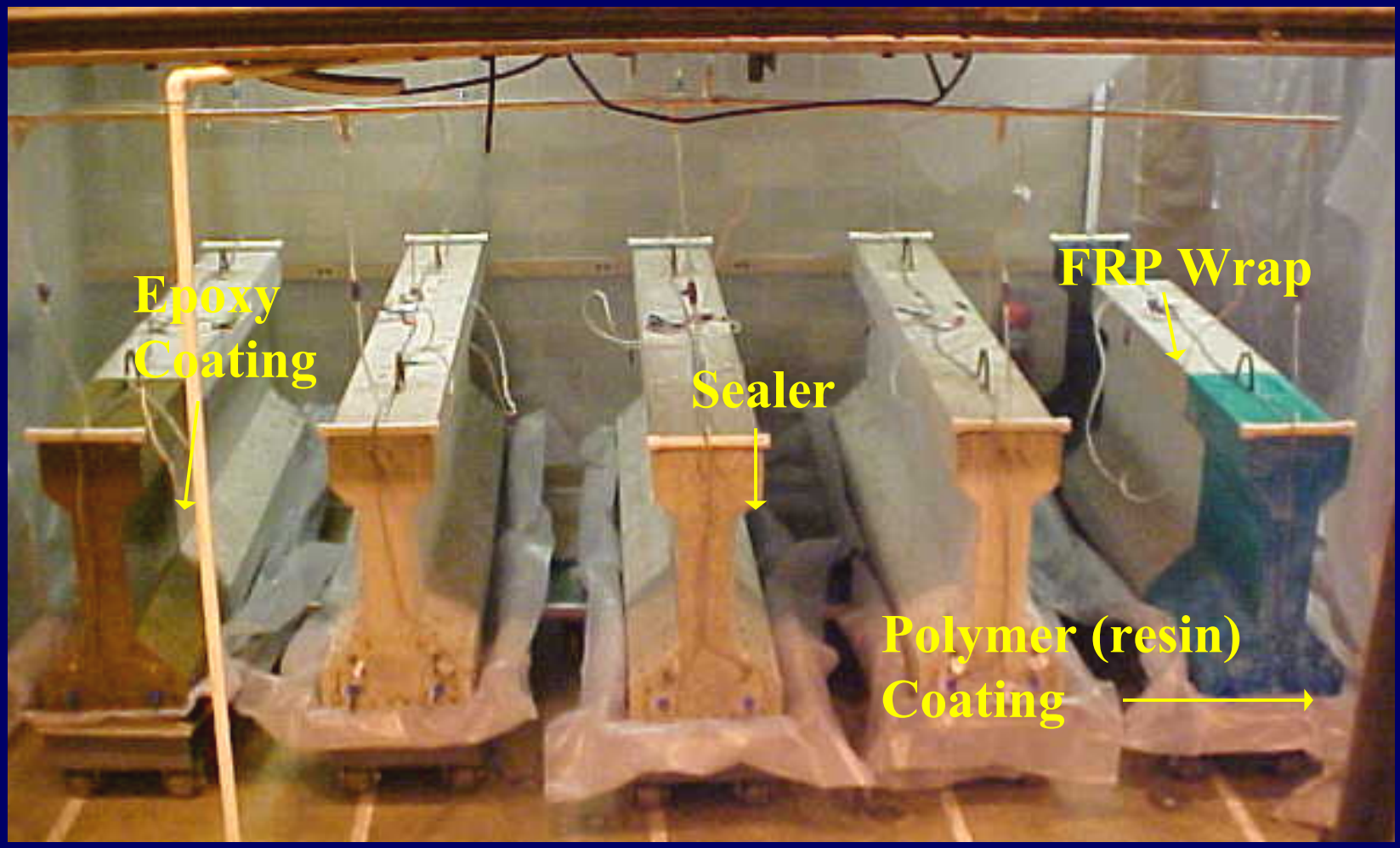


Salt-Water Distribution System



An electrical potential was also applied to accelerate corrosion and speed up chloride intrusion.

Experimental Set-up



Repair Materials

- Carbon Fiber Reinforced Polymer (CFRP)
  - REPLARK 30 manufactured by Mitsubishi Chemical Corporation
  - Consists of: carbon fiber fabric, primer, putty, and resin
  - 2 layers at 90° to one another (after application of primer and putty)
- Polymer (Resin) Coating
  - The resin component of the RELPLARK 30 system
  - 2 coats applied with paint roller (after application of primer and putty)

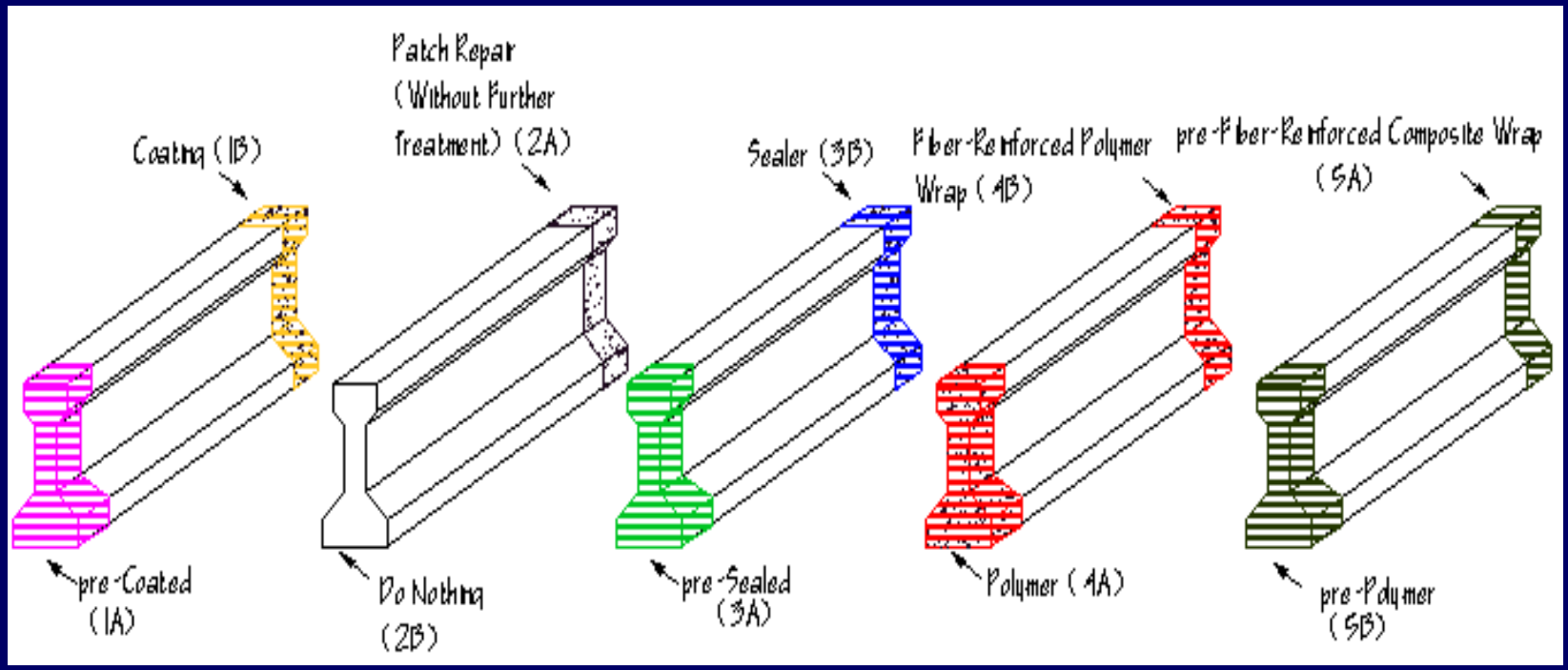
Repair Materials

- Epoxy Coating
  - MASTERSEAL GP Epoxy Sealer
  - 2 coats
- Sealer
  - MASTERSEAL SL 40 VOC
  - A solvent based silane penetrating sealer
  - 2 coats

Repair Materials

- Patch Material
  - Vericoat Supreme: a one component, microsilica and latex modified, nonsag repair mortar produced by Euclid Chemical Company
  - Designed for trowel applied vertical and overhead repairs
- Patch Material Bond Agent
  - CORR-BOND: composed of specialty water based epoxy and selected cementitious components produced by the Euclid Chemical Company

Repair Plan

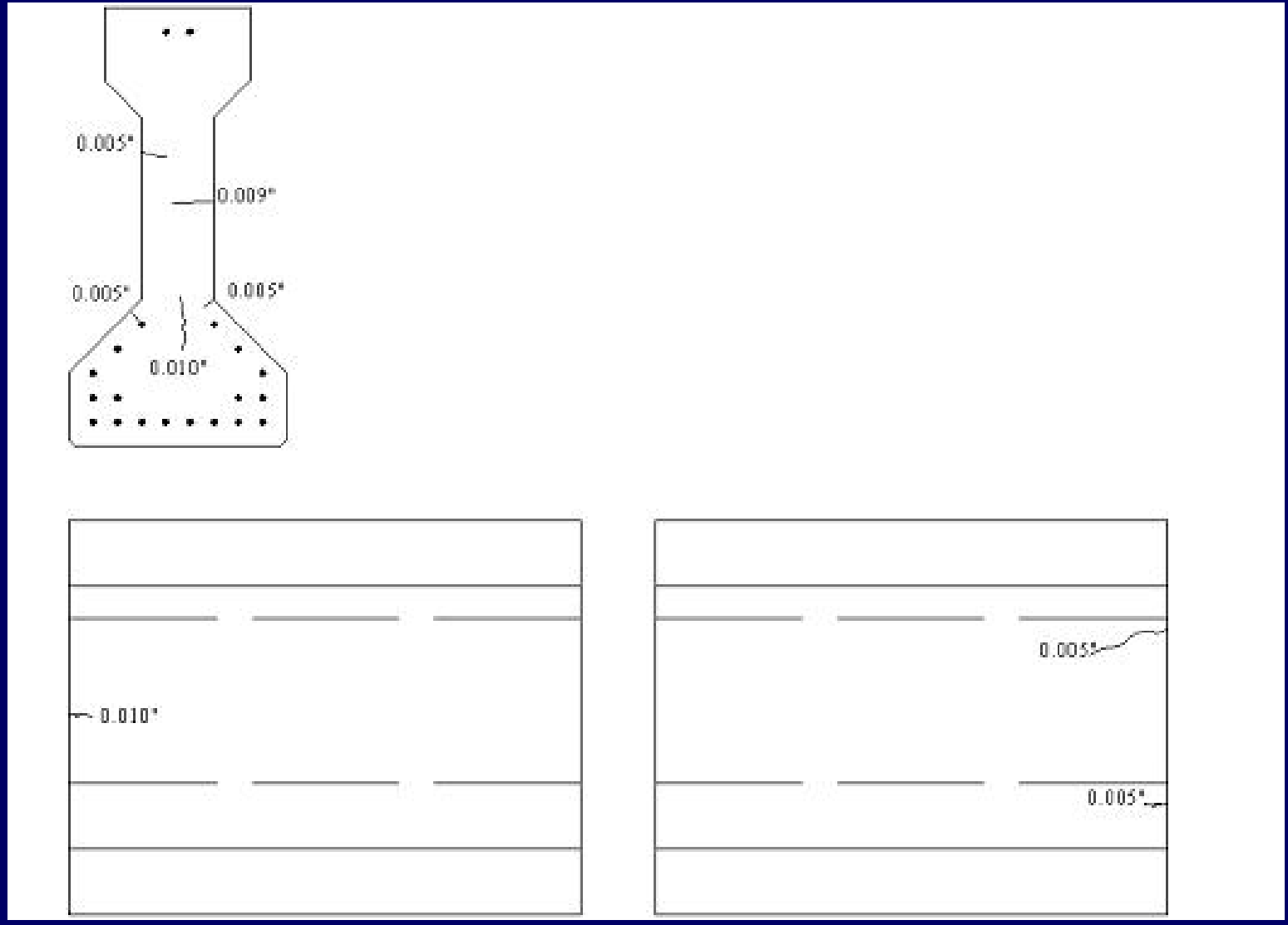

Coating (1B)
Patch Repair (Without Further Treatment) (2A)
Sealer (3B)
Fiber-Reinforced Polymer Wrap (4B)
pre-Fiber-Reinforced Composite Wrap (5A)
pre-Coated (1A)
Do Nothing (2B)
pre-Sealed (3A)
Polymer (4A)
pre-Polymer (5B)

Comparative Chloride Content Ratings

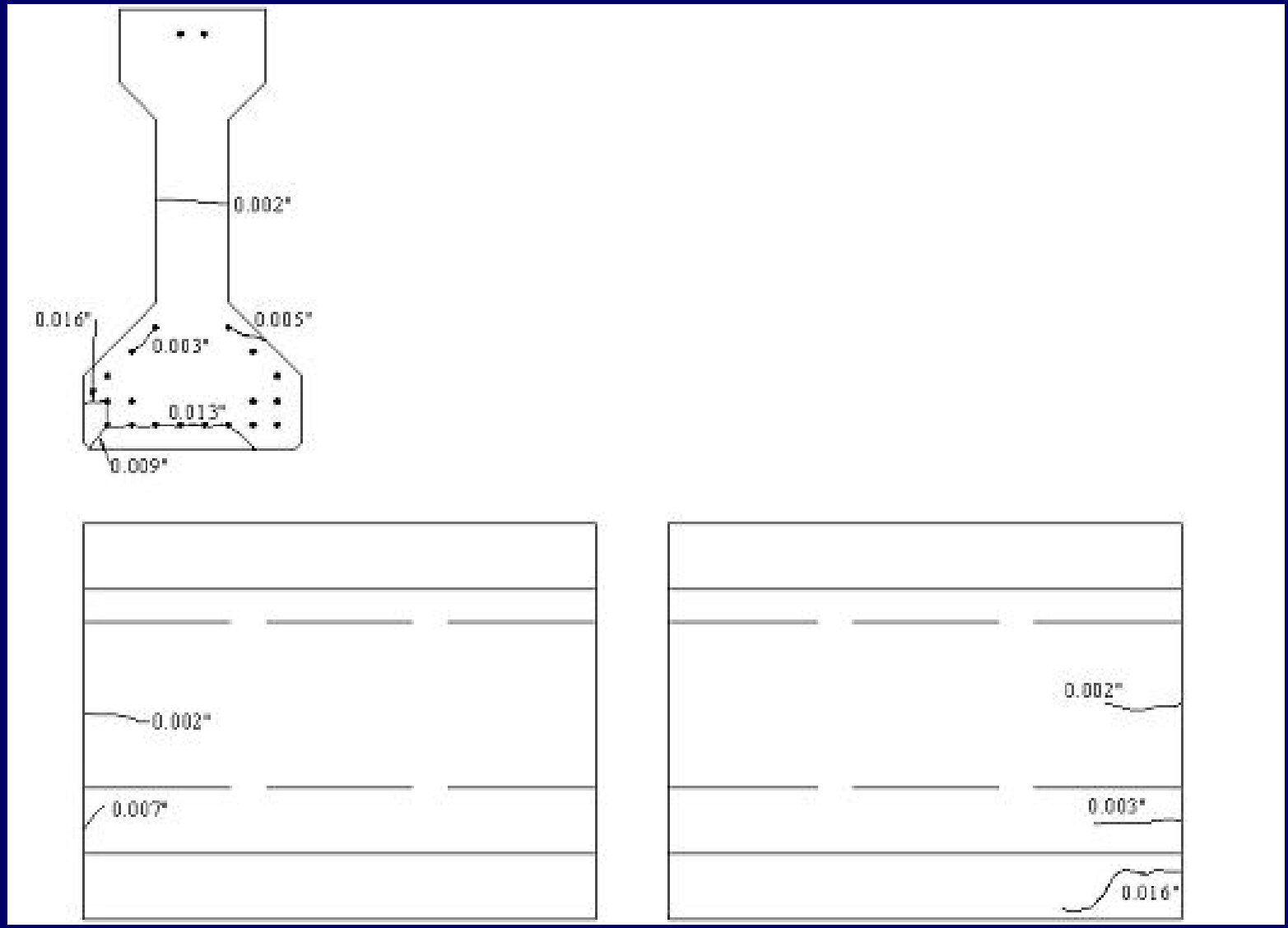
Beam-End	Rating at 0.75 in.	Rating at 1.5 in.	Ave. Rating
1A	1	1	1
1B	3	2	2.5
2A	3	1	2
2B	8	8	8
3A	1	1	1
3B	2	2	2
4A	4	5	4.5
4B	3	2	2.5
5A	1	1	1
5B	1	2	1.5

Ratings based on a range from 1 to 8 (1 best, 8 worst)
White rows correspond to beam-ends that were treated after 6 months of exposure.

Crack Map – 1A (18 Months)



Crack Map – 2A (18 Months)



Dissection – 2B

Overall Assessment

Beam End	Description	Chlorides	Cracking	Corrosion	Overall Rating
1A	Epoxy Coated From Day 1	1	2	3	**6**
1B	Epoxy Coated After 6 Months of Exposure	2.5	4	7	**13.5**
2A	No Treatment Applied	2	6	5.5	**13.5**
2B	Patch Repair After 6 Months of Exposure	8	7	8	**23**
3A	Silane Sealer Applied from Day 1	1	5	3.5	**9.5**
3B	Silane Sealer Applied After 6 Months of Exposure	2	8	5.5	**15.5**
4A	Polymer Resin Coating Applied After 6 Months Exp	4.5	3	6	**13.5**
4B	FRP Wrap Applied After 6 Months of Exposure	2.5	1	7	**10.5**
5A	Polymer Resin Coating Applied From Day 1	1	1	2	**4**
5B	FRP Wrap Applied From Day 1	1.5	1	2	**4.5**

Conclusions

- Experimental work:
  - The best overall results were obtained when either FRP wrap or polymer coatings were applied from Day 1
  - The application of treatments after 6 months of exposure was far less effective than treatment on Day 1
  - Epoxy coating was the next best effective method

Recommendations

- Use polymer coating or epoxy coating on beam ends in new projects prior to installation in the field.
- For existing bridges, apply either polymer coating or epoxy coating as early as possible before chloride contamination and corrosion take hold

Recommendations (Cont.)

- When corrosion and damage is advanced, patch alone would not be durable. Consider coating the patch with polymer or epoxy coatings.
- These results can equally apply to pier caps, columns, and abutments.